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Technical Note 441

EVALUATION OF METHODS FOR PROTECTING BURIED COLD
PIPES FROM EXTERNAL CORROSION AT CHINA LAKE, CALIFORNIA

25 June 1962

by:
H. R. Joerding

U. S. NAVAL CIVIL ENGINEERING LABORATORY
PORT HUENEME, CALIFORNIA

NO OTS

INTRODUCTION

The desert soil at the Naval Ordnance Test Station, China Lake, California has a high concentration of minerals, particularly in the dry lake beds, and has created a serious corrosion problem for underground pipes. These pipes have had short life because of extensive outer-surface corrosion. For example, a butane gas distribution line consisting of a 2-inch standard weight black steel pipe, asphalt coated and wrapped, failed in approximately one year. In another case, an uncoated, cast iron water pipe failed after a few years of service. Because of such failures, a test was established in an alkali-flat at NOTS to evaluate various pipe insulating materials. The first three inspections have been previously reported, and this report contains results of the fourth and fifth inspections.

DESCRIPTION OF TEST INSTALLATION

Nine 60-foot sections of both 2-inch bare and 2-inch insulated test pipe were laid in parallel trenches 3 feet deep and spaced 4 feet apart. Three sections are bare. One of these sections is galvanized steel, the second is black steel, and the third is copper. A fourth mixed-pipe section is also bare and consists of 20-foot lengths of galvanized steel, black steel, and copper, dielectric coupled to form one 60-foot section. The five remaining sections consist of steel pipe covered by a variety of insulating materials. The test pipes are connected to an existing 10-inch asbestos covered pipe carrying cold water. The connections are shown in Figure 1. The three 60-foot sections of bare pipe were installed in July 1960. The mixed section of bare pipe and the five sections of insulated pipe were installed in June 1958. A detailed description of each section of pipe is as follows:

1. Bare galvanized steel pipe: Type I, standard weight. Zinc coating conforms to Federal Specification WW-P-406a.
2. Bare black steel pipe: Type I, standard weight. Conforms to Federal Specification WW-P-406a.
3. Bare copper pipe: Type K, straight drawn tube. Conforms to Federal Specification WW-T-799a.
4. Bare galvanized steel - black steel - copper pipe: Each length conforms to the weights and specifications for the corresponding type above. The dielectric couplings used between each length have a metallic cover with a threaded dielectric insert.

5. Steel pipe coated with bituminous coating: Coating consists of one coat of coal tar primer, 10 mils thick, covered by a coat of coal tar enamel also 10 mils thick. The coating was applied according to Specification 34Yc for Type I protective system and conforms to MIL-P-15147.

6. Steel pipe wrapped with plastic tape: The tape is three inches wide, 10 mils thick and is made of polyvinylchloride. It is spirally wrapped with a 1/2-inch overlap. The tape does not conform to a military specification.

7. Steel pipe wrapped with resin-impregnated glass cloth: The cloth is three inches wide and is about 15 mils thick. It is spirally wrapped with a 1/2-inch overlap. The glass cloth conforms to MIL-C-19663 and the resin to MIL-R-7575A.

8. Steel pipe with unheated Gilsonite: An asphaltic resinous material surrounding the steel pipe in granular form and extending radially five inches; no heat was applied to the pipe to melt and consolidate the gilsonite.

9. Steel pipe with heated Gilsonite: An asphaltic resinous material surrounding the steel pipe in granular form and extending radially five inches. The pipe was heated for a time which melted the asphaltic material and consolidated it around the pipe.

INSPECTION PROCEDURE

The test pipes are inspected periodically to visually determine their condition. Originally, inspections were made annually, but now are made semi-annually because corrosion is accelerating. New test holes are dug at each inspection so that the condition of the pipes can be determined in undisturbed earth. The amount of rust and corrosion of the pipe is observed and recorded; representative areas are photographed. Samples of the soil and ground water are taken at each inspection and are analyzed later. Since different portions of the pipes are exposed at each inspection and the height and chemical content of the ground water continually varies throughout the year, variations in the condition of the pipe will occur.

RESULTS

a. Fourth Inspection, July 1961

Inspection holes were dug near the ends of each test pipe in soil undisturbed by previous inspections. The pipes were approximately two inches above the water table and the soil surrounding the

pipes and insulation appeared to be saturated.

Individually trenched bare pipes. The galvanized steel pipe had acquired a cover of light rust and small flakes of loose scale. There was no visual evidence of the zinc plating on the pipe surface. The black steel pipe had a cover of medium rust and moderately large flakes of loose scale. Some rust discoloration was observed in the surrounding soil. The copper pipe was uncorroded and had remained clean like a mill finish.

Mixed bare pipes dielectric coupled. Approximately 30 percent of the galvanized pipe was covered by a light rust and the other 70 percent was covered with zinc that had become dark gray in color. The black steel pipe had a cover of medium rust and scale. The appearance of this pipe was about the same as the one individually trenched except the rust was heavier and the scale tighter. The surrounding soil had acquired a heavy rust discoloration. The copper pipe was uncorroded and the surface was clean like a mill finish.

Remaining five pipes. Of these the one with the bituminous coating had a cover of medium rust and rather large flakes of loose scale. There was no evidence of the bitumen on the pipe, but the surrounding soil was highly discolored by it. Both the pipe wrapped with plastic tape and the pipe wrapped with resin-impregnated glass cloth were rust-free and appeared to be in excellent condition. There were a few places where the plastic tape had been nicked with shovels and these spots were rusted. Rust, however, had not spread beyond the nicks. Approximately 60 percent of the pipe insulated with unheated gilsonite had heavy rust and scale. The last pipe to be inspected had been covered with heated gilsonite. After the gilsonite was removed, it was found that about half of the pipe was covered with heavy rust despite good gilsonite consolidation.

b. Fifth Inspection, February 1962

Since the water table is higher during winter months, most of the pipes were submerged at the fifth inspection, but some were partly out of the water because they were located where the water table was lower.

Individually trenched bare pipes. The galvanized pipe was completely covered with a light to medium rust and small flakes of loose scale; no zinc plating remained on the pipe. The pipe's condition remained practically unchanged from that in the July 1961 inspection, except perhaps that the rust was slightly heavier. The black steel pipe was heavily rusted with a tight scale. The copper pipe was dimpled by small pock marks and had the appearance of having been given an acid bath.

Mixed bare pipes dielectric coupled. What was left of the zinc coating of the galvanized pipe had turned black in color and the remaining surface, approximately 60 percent, was covered by a light, loose rust. The black steel pipe had a cover of light, loose rust, but no visible scale. The copper pipe was pock marked and in much the same condition as the individually trenched copper pipe with the appearance of having been given an acid bath.

Remaining five insulated pipes. The section with the bituminous coating had a thin hard layer of the bitumen on its surface but the layer was badly chipped by shovels. These spots were beginning to rust. The last inspection reported that the surrounding soil was highly discolored by the bitumen. Apparently the bitumen redeposits on the pipe when the temperature of the soil decreases. Both the plastic-tape-wrapped and the resin-impregnated glass cloth wrapped pipes were in excellent condition. The pipe with the unheated gilsonite around it had a cover of medium rust and a tight scale; the pipe with the heated gilsonite was covered with medium rust.

c. Soil and Ground Water Analyses

Samples of the soil and the ground water are taken at each inspection. Chemical analyses of all samples taken thus far are given in Table I and Table II.

Table I. Soil Electrolyte Analysis (parts per million)

Date of Sample	Sample No.	Hydroxides (OH)	Carbonates (CO ₃)	Bicarbonates (HCO ₃)	Chlorides (Cl)	Sulphates (SO ₄)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Fe & Al Oxides (Fe ₂ O ₃ , Al ₂ O ₃)	Hydrogen ion Concentration (pH)
Oct 59*	1	0	384	329	9067	2941	64	5	8921	----	8.9
	2	0	552	305	4895	1336	240	15	3934	----	9.1
	3	54	1812	0	9577	2602	280	29	8542	----	9.4
Oct 60	1	0	20	85	1700	222	537	267	897	138	9.2
Jul 61	1	0	0	49	4884	754	44	29	1660	128	8.6
	2	0	0	58	6648	1525	107	21	3380	112	8.3
Feb 62**	1	0	Trace	177	1038	138	26	Trace	764	0	8.2
	2	0	0	159	1475	203	18	2	1096	0	7.8
	3	0	0	171	1100	147	18	5	820	0	8.1
	4	0	Trace	183	488	50	18	4	385	0	8.0

* Analysis by Hornkohl Laboratories, Bakersfield, California

** Analysis by Fruit Growers Laboratory, Santa Paula, California

Table II. Ground Water Analysis (parts per million)

Date of Sample	Hydroxide (OH)	Carbonates (CO ₃)	Bicarbonates (HCO ₃)	Chlorides (Cl)	Sulphates (SO ₄)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Silica (SiO ₂)	Fe & Al Oxides (Fe ₂ O ₃) (Al ₂ O ₃)	Total Dissolved Solids	Hardness	Hydrogen ion Concentration, pH
Mar 59	0	36	74	8980	843	131	30	5006	52	37	15189	450	7.9
Oct 60	0	0	117	18500	1762	492	80	11320	177	458	32906	1551	8.0
Jul 61	0	142	65	38624	1972	291	68	30500	15	116	71793	1005	7.4
Feb 62*	0	0	189	23750	2764	290	47	16380	35	0	43422	920	7.7

* Analysis by Fruit Growers Laboratory, Santa Paula, California

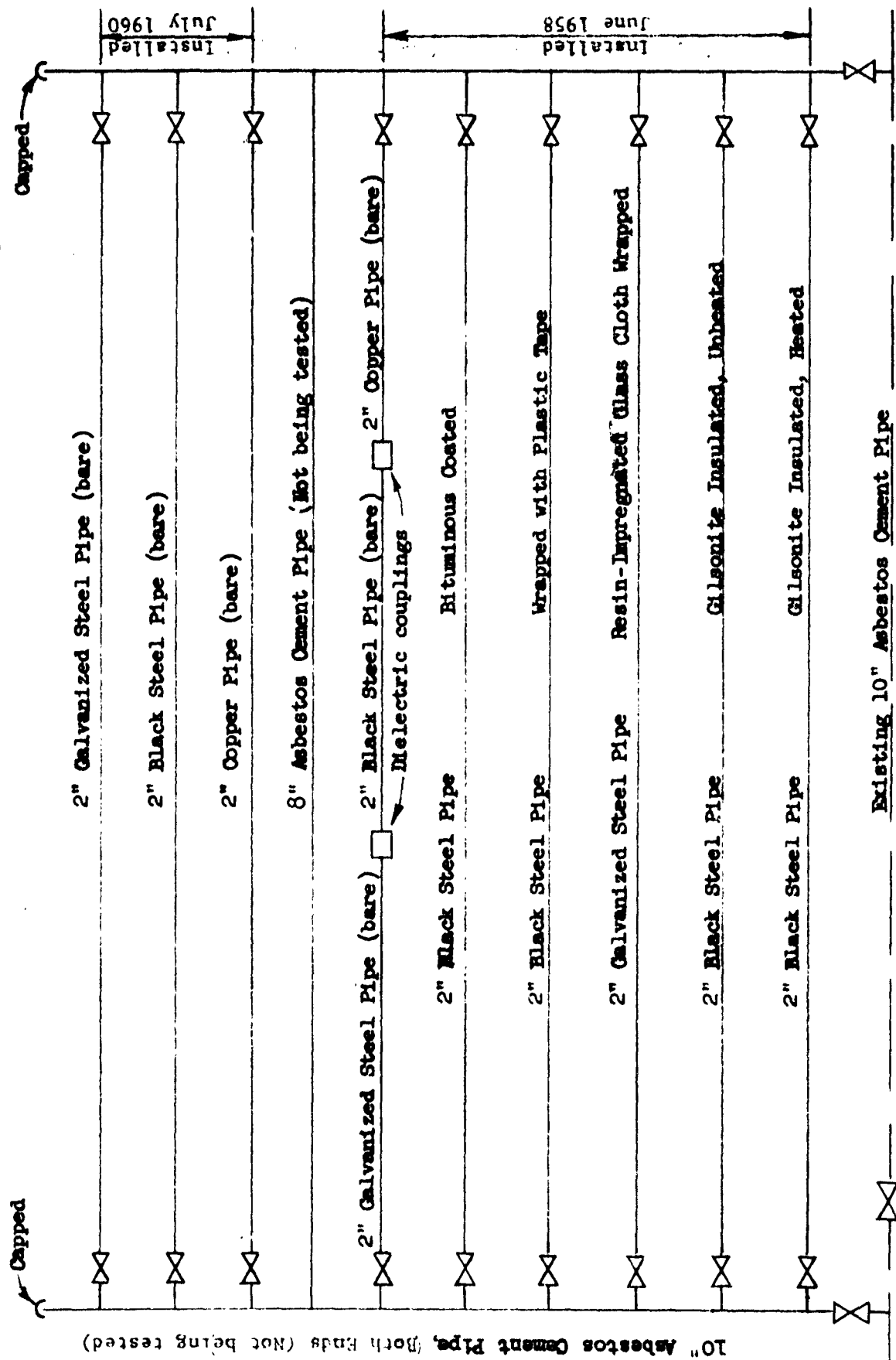


Figure 1. Diagram of Underground-Pipe Test Installation. Pipes are spaced 4 feet apart and Buried Approximately 3 Feet Deep